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METHODOLOGY FOR LABELING OIL PRODUCTS WITH ^{123}I

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ABSTRACT

The objective was the development a methodology to label organic compounds with radioactive iodine (^{123}I) from the reaction of organic compound with iodine nomochloride (ICL). The process begins with the production of ^{123}ICl from the oxidation of potassium iodate in acid medium. The ICL labeled with ^{123}I is extracted from aqueous phase using diethyl ether and then mixed with the organic compound to be labeled and the process is based on adding the radioactive iodine to the Carbon-Carbon double bonds of the organic compound. To measure the efficiency of the labeling process, in all stages samples were collected and the total activity of ^{123}I was measure. The results show a production yield of 82% for lubricant oil and 85% for gasoline and diesel.

1. INTRODUCTION

One of the major interests in the oil and natural gas industry is the security and safety in the transport and processing operations of crude and processed materials. In the whole oil cycle, from prospection of crude oil to transportation of oil products, is possible to use radioactive tracers to monitor and to evaluate the displacement of organic materials in different units in a process plant.

Many studies illustrate the successful implementation of this methodology in industrial and environmental process particularly in cases where conventional techniques cannot be applied due to the difficulty of direct access or impossible sampling. But in oil industry the great difficult is the choice of a specific organic radioactive tracer to evaluate units, such as distillation towers, pipelines or storage tanks. Using organic compounds labeled with radioactive iodine is one possibility to study the different units in an oil plant.

A great advantage of radioactive tracer technique is the possibility to measure in real time the operational conditions of the unit without affecting its normal operation. A small amount of radioisotope is injected into the process and radioactive scintillators detectors are positioned outside the unit to determine the position-and the displacement of the radioactive cloud and thus, if there is a problem inside a unit, it can be identified and located. The high sensitivity of the detection system allows using low concentrations of the radiotracer and this guarantee a low radiological risk to the workers and also not cause damage or radiological contamination equipment and environment.

2. METHODOLOGY

Iodine Monochloride (ICl) is used as carrier to link the radioactive iodine into double bounds of organic molecules. ICl molecule is polarized so it can be used for electrophilic aromatic substitution and because it is easily ionizable and reactive, ICl is more effective in this substitution reaction than others iodine compounds. One advantage of use ICl to label oil/oil products is that ICl can be prepare directly in the system used to labeling.

The production of ICl is due the reduction KIO_3 in acid medium. In a separating funnel KI is dissolved in distillated water and concentrated HCl (4N) is slowly added. A require activity of $Na^{123}I$ is added to the separating funnel with others reagents. Then, adds KIO_3 to the system. The reaction is shown is equation 1.

$$KIO_3 + 6HCl + 2KI \rightarrow 3ICl + 3KCl + 3H_2O \quad (1)$$

In aqueous solution both ICl and I_2 are slightly yellow, but in an organic phase iodine is yellow and iodine monochloride is purple and this is used to evaluate the production of ICl.

After the iodine extraction using a separating funnel, the organic solution changes to yellow while the yellow color intensity of aqueous phase is reduced. This is because the iodine monochloride was extracted. Open the funnel´s valve the aqueous phase is removed and then 5 ml of the organic compound to be label is add to the funnel and shake for 5 minutes. After each step a small sample (500 µl) of aqueous or organic phase was removed and the total activity was counted in a dose calibrator system.

3. RESULTS AND DISCUTION

3.1 – Total Activity Calibration System

The system, as shown in Figure 1, is compound of a NaI (2”x2”) scintillator detector totally cover with plumb with a special system to insert a small becker (5ml) focused with the detector´s face. In the calibration procedure around 50 µl of a sample to be measure is put inside the becker and the volume is completed with the same compound until 1 ml (total volume).

Figure 1 -. Calibration system to measure the organic iodine labeled samples [6]

To measure the correct activity a calibration curve was constructed using calibration samples with known activities and counts were measured considering the total area of the photopeak of 159 KeV gamma energy.

The calibration curves for lubricant oil are shown in Figure 2.

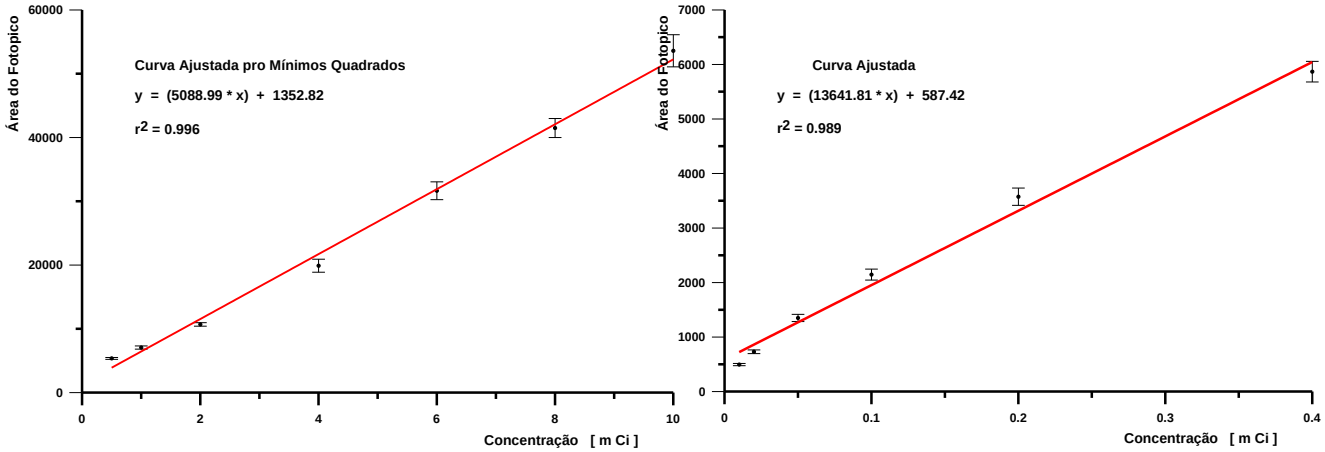

Fig2 - Calibration curves for ^{123}I activity in lubricant oil: (a) High concentration samples; (b) Low concentration samples

3.2 - Organic Molecules marked using Iodine Monochloride as carrier of ^{123}I

During the ICl chemical production, in each step 50 µl of aqueous and/or organic phase was removed and the total activity was measured in order to know the radioiodine transference. In figure 3 is shown the labeling process steps and when all the samples was collected.

Si sample is $Na^{123}I$ concentration in the beginning of labeling process. The Sw_1 is a water sample was collect in the beginning of the process in order to evaluate the ^{123}I transference from the aqueous solution to the organic phase. Water samples Sw_2 and Sw_3 are samples after the oil labeling and were collected after washing the ^{123}I–oil with fresh water (Sw_2) and hot water (Sw_3) to evaluate the stability of the labeling compound. The So_1, So_2 and So_3 are oil labeled samples and were collected after the labeling process (So_1), after the first wash (So_2) and after the second (So_3). All the samples activities were measure and the results are shown in table 1, all the results are in relation of the $Na^{123}I$ initial concentration

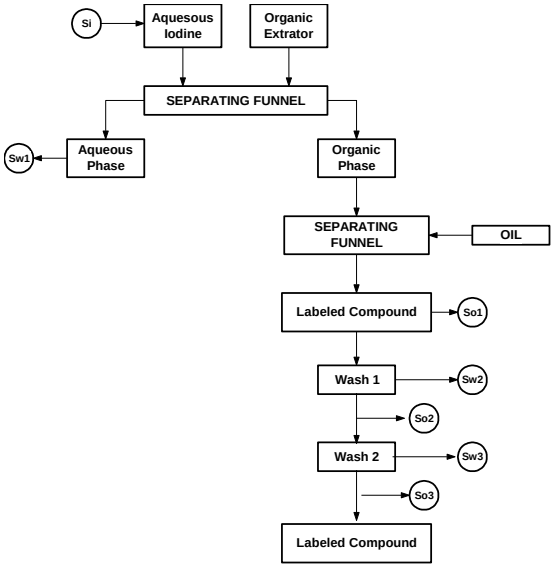

Figure 3 - Flowchart of sample collection in the ^{123}I oil labeling process: (Si)-Na^{123}I initial concentration; (Sw) – water samples; (So) – oil samples

Table 1. ^{123}I Samples activity

Sample	Sw1	Sw2	Sw3	So1	So2	So3
Activity	7.8 %	1.4 %	1.2 %	84.6 %	83.6 %	82.4 %

The results show us that by 85 % of inimical ^{123}I concentration was transfer to the organic phase in the first steep. The radioactivity in Sw1 is mainly due small drops of diethyl ether in aqueous phase. After the water washes there is around 1.2 to 1.5% of labeling oil in water, this is due the separation of aqueous and organic phase was not so good. To separate the phases it´s necessary first centrifuge them.

3. CONCLUSIONS

With the procedure describe is possible to label an organic compound. The first test is done with new lubricant oil and we did the same with used lubricant oil, gasoline and diesel but for gasoline and diesel we didn´t repeat the test with hot water. All cases between 80 to 85 % of initial radioiodine was transfer to the organic compound.

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